a first layer of a [single] continuous electrically conductive, titanium alloy within a high aspect ratio contact opening in an insulating layer, wherein the titanium alloy comprises titanium and an element selected from the group consisting of zinc, cadmium, mercury, aluminum, gallium, indium, tin, silicon, germanium, lead, arsenic and antimony;

a second layer of titanium silicide coupled to the first layer; and

a fill coupled to the titanium alloy layer, wherein the fill comprises a metal selected from the group consisting of tungsten and aluminum.

REMARKS

Applicant has carefully reviewed and considered the Office Action mailed on December 3, 2003, and the references cited therewith.

Claims 51, 53-56, 60, and 66 are amended, no claims are canceled, and no claims are added; as a result, claims 51-56, 60-73, 75-78, and 81-85 are now pending in this application.

§112 Rejection of the Claims

Claims 51-56 and 60-72 were rejected under 35 USC § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicant regards as the invention. The rejection stated that, "it is unclear what Applicant intends by specifying that the electrically conductive titanium alloy is a 'single' layer."

Applicant has removed the word "single" from claims 51, 53, 55, 56, 60, and 66, and added the description "continuous." Applicant respectfully submits that the claims as amended are sufficient under 35 USC § 112, second paragraph. Reconsideration and withdrawal of the rejection is respectfully requested.

§102 Rejection of the Claims

Claims 51 and 53 were rejected under 35 USC § 102(e) as being anticipated by Kirlin et al. (U.S. Patent No. 6,320,213). Claim 51 was rejected under 35 USC § 102(b) as being anticipated by Dixit et al. (U.S. Patent No. 4,884,123).

The rejection states that:

> Regarding claims 51 and 53, Kirlin discloses in Figure 27 a via comprising an electrically conductive titanium alloy layer (322) formed overlying walls and an

> exposed base layer of a contact hole and a fill (324) coupled to the titanium alloy layer comprising aluminum (col 10, lines 26-30). The titanium alloy layer may comprise Ti-Mg-N (col 9, lines 1-24). With specific regard to claim 53, the titanium alloy layer is titanium aluminum nitride (col 9, lines 2-3).

Kirlin appears to show a TiSiN or TiAlN barrier layer 322. A metallization layer 324 appears to be coupled to the barrier layer 322. However, Kirlin does not show a continuous electrically conductive, titanium alloy layer formed overlying walls and an exposed base layer of a contact hole, and a barrier layer coupled to the titanium alloy layer.

In contrast, Applicant's claim 51, as amended, includes a continuous electrically conductive, titanium alloy layer formed overlying walls and an exposed base layer of a contact hole, and a barrier layer coupled to the titanium alloy layer. Further, Applicant's claim 53, as amended includes a continuous electrically conductive, titanium alloy layer formed overlying walls and an exposed base layer of a contact hole, wherein the titanium alloy layer comprises titanium and an element selected from the group consisting of zinc, cadmium, mercury, aluminum, gallium, indium, tin, silicon, germanium, lead, arsenic and antimony, and a barrier layer coupled to the titanium alloy layer.

Because the Kirlin reference does not show every element of Applicant's claims 51 and 53, a 35 USC § 102(e) rejection is not supported. Reconsideration and withdrawal of the rejection is respectfully requested with respect to Applicant's claims 51 and 53.

The rejection also states that:

> Dixit discloses a via comprising an electrically conductive nitride-free titanium alloy layer (20) such as titanium tungsten formed overlying walls and an exposed base layer of a . contact hole and a fill (22) comprising tungsten coupled to the titanium alloy layer (col 4, line 36- col 5, line10).

Dixit appears to show a barrier layer 20 coupled to a pure titanium layer 18, which is in turn overlying walls of a contact hole 16. Dixit does not, however, show a continuous electrically conductive, titanium alloy layer formed overlying walls and an exposed base layer of a contact hole, and a barrier layer coupled to the titanium alloy layer. In contrast, Applicant's claim 51, as amended, includes a continuous electrically conductive, titanium alloy layer formed

D

overlying walls and an exposed base layer of a contact hole, and a barrier layer coupled to the titanium alloy layer.

Because the Dixit reference does not show every element of Applicant's claim 51, a 35 USC § 102(b) rejection is not supported. Reconsideration and withdrawal of the rejection is respectfully requested with respect to Applicant's claim 51.

Allowable Subject Matter

Claims 52, 54, 61-65 and 67-72 were indicated to be allowable if rewritten to overcome the rejection(s) under 35 USC § 112, second paragraph, set forth in this Office Action and to include all limitations of the base claim and any intervening claims. Applicant respectfully submits that independent claims 51, 53, 60, and 66 as amended are in condition for allowance. Applicant therefore has not amended dependent claims 52, 54, 61-65 and 67-72 at this time.

Claims 55, 56, 60 and 66 were indicated to be allowable if rewritten or amended to overcome the rejection(s) under 35 USC § 112, second paragraph, set forth in this Office Action. Applicant has made amendments to claims 55, 56, 60 and 66 as detailed above. Applicant respectfully submits that the claims are now in condition for allowance.

Applicant acknowledges and thanks the Examiner for the allowance of claims 73, 75-78 and 81-85.

CONCLUSION

Applicant respectfully submits that the claims are in condition for allowance and notification to that effect is earnestly requested. The Examiner is invited to telephone Applicant's attorney at (612) 373-6944 to facilitate prosecution of this application.

If necessary, please charge any additional fees or credit overpayment to Deposit Account No. 19-0743.

Respectfully submitted,

GURTEJ S. SANDHU ET AL.

By their Representatives,

SCHWEGMAN, LUNDBERG, WOESSNER & KLUTH, P.A.
P.O. Box 2938
Minneapolis, MN 55402
(612) 373-6944

Date 3-3-03

By _____
David C. Peterson
Reg. No. 47,857

CERTIFICATE UNDER 37 CFR 1.8: The undersigned hereby certifies that this correspondence is being deposited with the United States Postal Service with sufficient postage as first class mail, in an envelope addressed to: Commissioner of Patents, Washington, D.C. 20231, on this 3rd day of March 2003.

Amy Moriarty
Name

_____
Signature

Clean Version of Amended Specification Paragraphs

Title: CHEMICAL VAPOR DEPOSITION OF TITANIUM
Application Serial No. 09/941,125

The paragraph beginning on page 4, line 20:

Brief Description of the Figures

Figure 1A is a cross-sectional view of a contact hole that has been etched through an insulative layer to an underlying semiconductor substrate.

Figure 1B is a cross-sectional view of the contact hole of Figure 1A, comprising titanium and titanium silicide film.

Figure 2 is a cross-sectional view of the contact hole of Figure 1A, comprising a film of second reducing agent.

Figure 3A is a cross-sectional view of a contact hole as in Figure 1A, including additional structures according to an embodiment of the invention.

Figure 3B is a block diagram of a memory.

The paragraph beginning on page 9, line 9:

Subsequently, the integrated circuit 19 is annealed at a temperature of between approximately 250 to 750 degrees Celsius. Alternatively, the temperature may range from approximately 250 to 800 degrees Celsius. In one embodiment, the temperature is approximately 700 degrees Celsius. As a result, the titanium in the layer 16 of titanium or titanium alloy proximate to the silicon is converted to titanium silicide (TiSi, $TiSi_2$, Ti_3Si_5 or combinations thereof) to form the low resistance device contact 18. For via level applications, the anneal is not required. The via comprises a tungsten or aluminum fill 42 on top of the layer 16 which is formed on top of a conductor (also represented by reference number 17) with an optional TiN layer 40 between layer 16 and the fill material 42.

Docket No. 303.676US5
WD #394631

Micron Ref. No. 92-0560.06

Clean Version of Pending Claims

CHEMICAL VAPOR DEPOSITION OF TITANIUM
Applicant: Gurtej Singh Sandhu et al.
Serial No.: 09/941,125

Claims 51-56, 60-73, 75-78, and 81-85, as of March 3, 2003 (date response to office action filed).

51. (Thrice amended) A via, comprising:

a continuous electrically conductive, titanium alloy layer formed overlying walls and an exposed base layer of a contact hole;

a barrier layer coupled to the titanium alloy layer; and

a fill coupled to the barrier layer, wherein the fill comprises a metal selected from the group consisting of tungsten and aluminum.

52. The via of claim 51, wherein the titanium alloy layer comprises titanium and zinc.

53. (Thrice amended) A via, comprising:

a continuous electrically conductive, titanium alloy layer formed overlying walls and an exposed base layer of a contact hole, wherein the titanium alloy layer comprises titanium and an element selected from the group consisting of zinc, cadmium, mercury, aluminum, gallium, indium, tin, silicon, germanium, lead, arsenic and antimony;

a barrier layer coupled to the titanium alloy layer; and

a fill coupled to the barrier layer, wherein the fill comprises a metal selected from the group consisting of tungsten and aluminum.

54. (Amended) The via of claim 51, wherein the barrier layer includes a titanium nitride layer interposed between the titanium alloy layer and the fill.

55. (Thrice amended) A via, comprising:

a continuous electrically conductive, titanium alloy layer formed overlying walls and an exposed base layer of a contact hole;

a fill comprising a metal selected from the group consisting of tungsten and aluminum; and

a titanium nitride layer interposed between the titanium alloy layer and the fill.

56. A via, comprising:

a continuous electrically conductive, titanium alloy layer formed overlying walls and an exposed base layer of a contact hole, wherein the titanium alloy layer comprises titanium and an element selected from the group consisting of zinc, cadmium, mercury, aluminum, gallium, indium, tin, silicon, germanium, lead, arsenic and antimony;

a fill comprising a metal selected from the group consisting of tungsten and aluminum; and

a titanium nitride layer interposed between the titanium alloy layer and the fill.

60. (Thrice amended) A via, comprising:

a first layer of a continuous electrically conductive, titanium alloy within a contact opening in an insulating layer, wherein the titanium alloy comprises titanium and an element selected from the group consisting of zinc, cadmium, mercury, aluminum, gallium, indium, tin, silicon, germanium, lead, arsenic and antimony;

a second layer of titanium silicide coupled to the first layer; and

a fill coupled to the titanium alloy layer, wherein the fill comprises a metal selected from the group consisting of tungsten and aluminum.

61. The via of claim 60, wherein the first layer includes a titanium zinc alloy.

62. The via of claim 60, further including a titanium nitride layer interposed between the titanium alloy layer and the fill.

63. The via of claim 60, wherein the first layer is coupled to a sidewall of the contact opening.

64. The via of claim 60, wherein the second layer is coupled to an exposed semiconductor surface.

65. The via of claim 60, wherein the contact opening includes a high aspect ratio contact opening.

13 66. (Thrice amended) A via, comprising:

a first layer of a continuous electrically conductive, titanium alloy within a high aspect ratio contact opening in an insulating layer, wherein the titanium alloy comprises titanium and an element selected from the group consisting of zinc, cadmium, mercury, aluminum, gallium, indium, tin, silicon, germanium, lead, arsenic and antimony;

a second layer of titanium silicide coupled to the first layer; and

a fill coupled to the titanium alloy layer, wherein the fill comprises a metal selected from the group consisting of tungsten and aluminum.

67. The via of claim 66, wherein the first layer includes a titanium zinc alloy.

68. The via of claim 66, further including a titanium nitride layer interposed between the titanium alloy layer and the fill.

69. The via of claim 66, wherein the insulating layer includes borophosphous silicate glass (BPSG).

70. The via of claim 66, wherein the insulating layer includes silicon dioxide (SiO_2).

71. The via of claim 66, wherein the first layer is coupled to a sidewall of the high aspect ratio contact opening.

72. The via of claim 66, wherein the second layer is coupled to an exposed semiconductor surface.

73. A via, comprising:

a first layer of an electrically conductive, titanium zinc alloy on a sidewall of a high aspect ratio contact opening in an insulating layer;

a second layer of titanium silicide formed overlying an exposed semiconductor base layer of the contact hole;

a fill coupled to the titanium zinc alloy layer, wherein the fill comprises a metal selected from the group consisting of tungsten and aluminum.

75. The via of claim 73, further including a titanium nitride layer interposed between the titanium zinc alloy layer and the fill.

76. The via of claim 73, wherein the insulating layer includes borophosphous silicate glass (BPSG).

77. The via of claim 73, wherein the insulating layer includes silicon dioxide (SiO_2).

78. A via, comprising:

a first layer of an electrically conductive, titanium zinc alloy within a contact opening in an insulating layer, wherein the first layer is produced using a method including:

forming a seed layer supported by a substrate by combining a first precursor with a first reducing agent;

forming the titanium layer supported by the substrate by combining a titanium-containing precursor with the seed layer; and

filling the remaining space of the contact opening with a metal selected from the group consisting of tungsten and aluminum.

81. The via of claim 78, further including a second layer of titanium silicide coupled to the titanium zinc alloy.

82. The via of claim 78, further including a titanium nitride layer interposed between the first layer and the fill.

83. The via of claim 81, further including a titanium nitride layer interposed between the second layer and the fill.

84. The via of claim 78, wherein the first layer is coupled to a sidewall of the contact opening.

85. The via of claim 78, wherein the first layer is coupled to a high aspect ratio contact opening.